



Defoliation patterns in signal grass tillers with varying heights in the same pasture

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ABSTRACT. The experiment was carried out to evaluate the patterns of defoliation in plants of various heights in the same pasture of *Brachiaria decumbens* cv. Basilisk under continuous stocking with cattle. Four plant heights were evaluated (10, 20, 30 and 40 cm) in the same managed sward, with mean height equal to 25 cm. A randomized blocks design was used, with two replications. Defoliation frequency increased linearly along with plant height in the same pasture. Defoliation intensity, number of defoliations in leaf blade and percentage of leaf blade grazed per tiller also increased linearly along with plant height. The defoliation interval decreased linearly according to plant height. The quadratic model was adequately fitted into grazing efficiency data, reaching the highest value (98%) at the sward site with 35 cm plants. The percentage variation in signal grass height showed a negative linear response with initial plant height. The structure of the pasture, characterized by the diversity in plant heights, is simultaneously the cause and consequence of the variability in defoliation patterns in individual tillers, which occur on the horizontal plane of the pasture.

Keywords: *Brachiaria decumbens*, forage losses, grazing, horizontal pasture sward.

Padrões de desfolhação em perfilhos de capim-braquiária com alturas variáveis no mesmo pasto

RESUMO. O experimento foi conduzido para avaliar os padrões de desfolhação em plantas com alturas variáveis no mesmo pasto de *Brachiaria decumbens* cv. Basilisk sob lotação contínua com bovinos. Foram avaliadas quatro alturas de plantas (10, 20, 30 e 40 cm) no mesmo pasto manejado com altura média de 25 cm. Adotou-se o delineamento em blocos ao acaso com duas repetições. A frequência de desfolhação aumentou linearmente com a altura da planta no mesmo pasto. A intensidade de desfolhação, o número de desfolhações na lâmina foliar e o percentual de lâmina foliar pastejada por perfilho também incrementaram de forma linear com a altura da planta. O intervalo de desfolhação diminuiu linearmente com a altura da planta. O modelo quadrático foi ajustado adequadamente aos dados de eficiência de pastejo, obtendo-se o valor máximo (98%) no local do pasto com plantas de 35 cm. A variação percentual na altura do capim-braquiária apresentou resposta linear negativa com a altura inicial da planta. A estrutura do pasto, caracterizada pela sua diversidade de alturas de plantas, é, concomitantemente, causa e consequência da variabilidade dos padrões de desfolhação em perfilhos individuais que ocorrem no plano horizontal do pasto.

Palavras-chave: *Brachiaria decumbens*, perda de forragem, pastejo, estrutura horizontal do pasto.

Introduction

The defoliation pattern of a given pasture is represented by the sum of the defoliation patterns of its tillers. In that sense, pasture defoliation can be studied by evaluating the grazing frequency and intensity of its individual tillers.

Defoliation intensity can be defined as the proportion of initial leaf length that is removed during grazing. In this case, grazing intensity refers only to the removal of leaf area. Conversely, defoliation frequency corresponds to the number of defoliations that occurs in a leaf or tiller during a

given time period. Defoliation frequency, when given as a percentage in a sward under continuous stocking, corresponds to the proportion of the pasture that is grazed daily (LEMAIRE et al., 2009).

By determining the frequency and intensity of defoliation, as well as leaf longevity, it is possible to estimate grazing efficiency (CARVALHO et al., 2007). The relevance of knowing grazing efficiency lies in the fact that pasture usage is a premise for its transformation into an animal product, although the possibility should be acknowledged of obtaining high growth rates and pasture intake with higher rates of leaf senescence (PONTES et al., 2004).

It should also be considered that, in the same sward under continuous stocking with relatively constant average height, the selective behavior of ruminants results in differences in the defoliation patterns of its tillers in the horizontal plane of the sward. This results in plants with different structures in the same pasture (SANTOS et al., 2010; SANTOS et al., 2011a), increasing sward morphological heterogeneity, in effect making studies on plant-animal interface under grazing more complex (GONÇALVES et al., 2009).

Moreover, the difference in the defoliation patterns of tillers in the horizontal plane of the sward, although little understood, determines horizontal sward structure, which affects forage plant growth (SANTOS et al., 2011a), forage harvesting efficiency, as well as intake behavior and performance of animals (CARVALHO et al., 2007; GONÇALVES et al., 2009).

Thus, the objective of this work was to evaluate the influence of natural variations in plant height on the same sward on defoliation patterns in tillers of *Brachiaria decumbens* cv. Basilisk, managed under continuous stocking with cattle.

Material and methods

This work was carried out between November 2007 and May 2008 at an area of *Brachiaria decumbens* cv. Basilisk (Stapf.) pasture established in 1997, belonging to the Forage Sector of the Animal Science Department of the Federal University of Viçosa, Minas Gerais State, Brazil (20°45' S; 42°51' W; 651 m). The experimental area consisted of two paddocks (replications) with approximately 0.30 ha each, in addition to a spare area. The soil in the experimental area is a clayish Red-Yellow Latosol. Chemical analysis of the soil, performed 0-20 cm deep at the start of the experimental period, showed the results described in Table 1.

Table 1. Chemical analysis of the soil in the experimental area, corresponding to the layer between 0 and 20 cm of depth.

pH (H ₂ O)	P (Mehlich-1) -----mg dm ⁻³ -----	K	Ca ²⁺	Mg ²⁺	Al ³⁺
			-----cmol _c dm ⁻³ -----		
5.1	2.9	85	2.05	0.45	0.19

During the evaluation period, climate data were recorded at a weather station located 500 m from the experimental area (Figure 1).

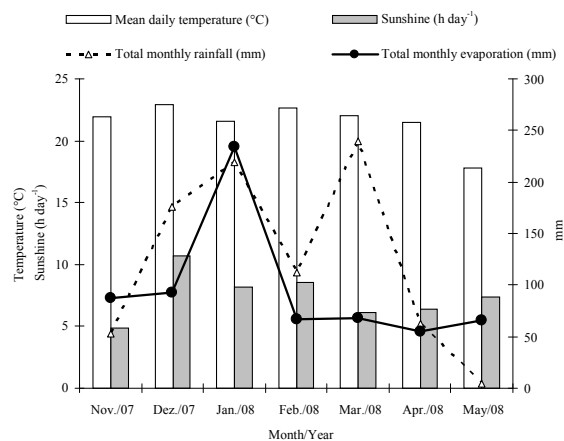


Figure 1. Monthly averages for mean daily temperature, sunshine, total monthly rainfall and total monthly evaporation between November 2007 and May 2008, in Viçosa, Minas Gerais State, Brazil.

Phosphate fertilization took place on January 16, 2008, with the application of 70 kg ha⁻¹ of P₂O₅, as single superphosphate, throughout the entire experimental area. Nitrogen fertilization, in the form of urea, took place in three applications of 50 kg ha⁻¹ of N in the late afternoon of each application date (January 16, February 26 and April 7, 2008).

Starting in November 2007, the paddocks were managed under continuous stocking with cattle, with varying stocking rates in order to maintain mean sward height around 25 cm. To that end, sward height was monitored twice a week, by measuring height values at 50 sites per paddock, with an instrument built using two PVC pipes, one inside the other. The inner pipe had a scale with 1 cm markings and a fixed metallic rod (nail) which slides along a slit in the outer pipe. The criterion for measuring sward height was the distance between the soil surface and the live leaves on the upper canopy. In each paddock, whenever mean sward height was above or below 25 cm, animals were placed in or removed from the paddocks, respectively, until the intended height was reached.

Crossbred Holstein x Zebu growing bulls were used in the experiment, averaging 200 kg. During the experimental period, mean stocking rate in the paddocks was 3.4 AU ha⁻¹.

Four plant heights (10, 20, 30 and 40 cm) were evaluated in the same sward managed at mean height of 25 cm, which was possible due to the natural spatial variability in the vegetation (SANTOS et al., 2010; SANTOS et al., 2011a). A randomized blocks design was adopted, with two replications. Thus, each evaluated plant height represented an experimental unit, while each paddock was a replication.

In early January 2008, the signal grass pasture was infested by the Striped Grass Looper *Mocis latipes*, effectively putting an end to field evaluations, which had begun in mid-December 2007. With the infestation, the animals were removed from the paddocks and Decis 25EC pesticide was applied at a dose of 200 mL ha⁻¹. The paddocks were used again, under grazing and following the same management as before, starting only in mid-February 2008.

Concomitantly to evaluations of morphogenesis (SANTOS et al., 2011a) and sward structure (SANTOS et al., 2010), defoliation patterns in signal grass tillers were evaluated at pasture sites in which plants initially measured 10, 20, 30 and 40 cm. In each paddock, four tillers were tagged from each height class, totaling 16 tillers, using a color plastic ring, identifying four tillers at each studied pasture site. Two data collection cycles were evaluated, of at least four weeks each. For each cycle, a new group of tillers was selected for evaluation.

With the aid of a grading ruler, measurements of leaf blade lengths were made in the marked tillers, twice a week. Expanded leaf length was measured from the tip of each leaf to its ligula. The same procedure was adopted in the case of expanding leaves, using the ligula of the last expanded leaf as reference. For senescent leaves, length was measured as the distance between the furthest senescence point and the ligula of the leaf. The number of grazed leaves per tiller was recorded as well. From these data, the following variables were calculated:

Number of grazed leaves per tiller: average number of leaves per tiller with partial or total leaf blade removal, expressed as a percentage of the number of live leaves per tiller.

Defoliation intensity (InD): ratio between the length of leaf blade removed by grazing and initial length of expanded or expanding leaf blade, expressed as a percentage and obtained through the equation: $InD = (CIL - CAD)/CIL$, in which: CIL = initial blade length, CAD = length after defoliation.

Defoliation frequency (FqD): number of defoliations in expanded or expanding leaf blades during the evaluation period of the tiller, obtained through the equation: $FqD = ND / DIA$, in which: ND = number of defoliations, DIA = evaluation day of the tiller in question.

Possible number of defoliations: the product of leaf longevity (SANTOS et al., 2011a) and defoliation frequency.

Grazing efficiency: indicates the percentage of produced leaf blade effectively ingested by

animals; the calculation was performed according to Lemaire et al. (2009).

Forage loss: grazing efficiency value subtracted from 100%.

To determine the percentage variation in initial plant height in the same sward, six points were marked in each evaluated pasture area (10, 20, 30 and 40 cm), totaling 24 points per paddock. These points included those in which morphogenesis evaluations took place. On the day the markers were placed, the plants were measured at these points using a graduated ruler. About 30 days later (the evaluation cycle), plant height was measured once again at these same points. The variation in initial plant height was calculated as the difference between the height on the first and last days of the evaluation cycle, expressed as relative terms. Two 30-day evaluation cycles were carried out – the first between February 13, 2008 and March 10, 2008; the second between March 16, 2008 and April 15, 2008.

For data analysis, initially a descriptive comparison of the average response variables was made between the two evaluation cycles. Based on the results, a similarity was observed between both sets of data. Therefore, they were grouped together – for each response variable, the data measured in both evaluation cycles were used to generate a mean value. In each evaluation cycle and each paddock, the means were also obtained for all four tillers (in the case of defoliation pattern measurements) and all six plants (in the case of measurements of percentage variation in initial plant height), evaluated at all four sites in the same paddock (10, 20, 30 and 40 cm).

Later, analyses of variance and regression were carried out as a function of plant height in the same sward, for each characteristic; the tested models were linear and quadratic. The goodness of fit of each model was evaluated by the coefficient of determination and the significance of the regression coefficients, tested using the corrected t-test based on analysis of variance residuals.

Results and discussion

Defoliation frequency increased linearly ($p < 0.05$) along with plant height in the same signal grass pasture (Figure 2). This result demonstrates that during the height interval under study, cattle grazed preferentially on the taller plants of the signal grass sward, as opposed to shorter plants.

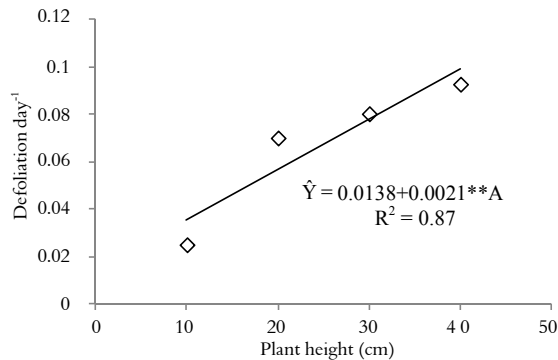


Figure 2. Defoliation frequency of the leaf blades in *B. decumbens* cv. Basilisk as a function of plant height in the same pasture; **Significant according to t-test ($p < 0.05$).

In general, shorter plants are preferred by animals for their higher rates of green leaf blade, which is the morphological component of pasture with the best nutritional value (SANTOS et al., 2008). Thus, no reduction in defoliation frequency would be expected in shorter plants. Moreover, animals ignore taller plants as they usually feature greater stem and senescent tissue mass (SANTOS et al., 2010), which have lower nutritional value (SANTOS et al., 2008). Nevertheless, the data in this experiment did not show such a response pattern (Figure 2), demonstrating that the dynamics of temporal variation in sward structure are complex and can be influenced by other factors, such as stocking rate, available forage mass and season of the year. In that regard, it is possible that, within the spectrum of evaluated height variables as well the morphological characteristics of signal grass (thin stem), cattle optimized their ingestive behavior by grazing on tall plants (40 cm). In fact, tall pastures can increase bite depth and consequently enlarge bite mass, which in turn is the main determinant factor of the amount of feed ingested by grazing animals (CARVALHO et al., 2007; GONÇALVES et al., 2009).

Defoliation frequency is positively related to the stocking density in swards managed under continuous stocking (LEMAIRE et al., 2009). Under these conditions, the greater forage mass and low stocking density in a pasture kept at greater mean height make it possible for animals to ingest their daily diet without roaming over a wider pasture area, resulting in lower defoliation frequency in individual tillers (PENNING et al., 1991). This response pattern occurs in swards with greater mean height; however, in the same pasture, under the same stocking density, different defoliation frequencies and intervals occur in plants (Figure 2), characterizing animal selectivity, which in turn creates spatial variability within the vegetation.

Defoliation intensity values increased according to plant height in the same signal grass sward (Figure 3). Once again, this result indicates that cattle removed greater amounts of forage during each defoliation events at the pasture sites featuring taller plants.

In general, defoliation intensity of leaf blades is lower in swards with greater mean height (LEMAIRE et al., 2009) due to the lower leaf/stem ratio, which results (among other factors) from the higher number of reproductive tillers in taller pastures (SANTOS et al., 2010). The presence of stems limits grazing depth and defoliation intensity of tillers as it constitutes a physical barrier (greater tissue resistance) to biting by grazing animals (BARTHAM; GRANT, 1984). However, it should be taken into account that the stem of signal grass is thinner and more malleable when compared to other tropical forage grasses, such as some species from genera *Panicum* and *Pennisetum*. As such, signal grass stems can have a less marked effect as a limiting morphological component to grazing depth for growing cattle, which would explain the greater defoliation intensity in taller plants (Figure 3).

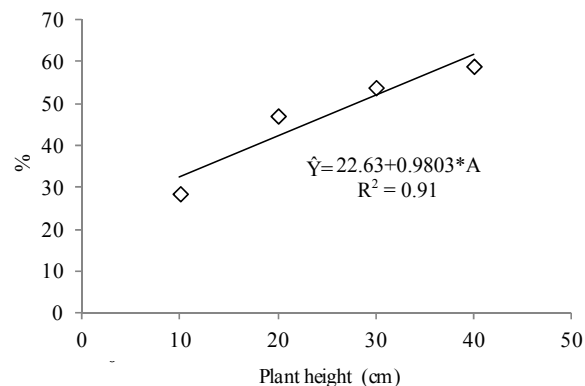


Figure 3. Defoliation intensity in leaf blades of *B. decumbens* cv. Basilisk as a function of plant height in the same sward; * Significant according to t-test ($p < 0.01$).

The increased defoliation frequency in taller plants (Figure 1) justifies the linear increase ($p < 0.01$) in the number of defoliation events in the leaf blade of taller tillers (Figure 4A).

For its part, the effect of plant height in increasing the number of defoliations during the lifespan of the leaf blade (Figure 4A) determined the increase ($p < 0.01$) in the percentage of leaf blades grazed per tiller of signal grass (Figure 4B).

From the data on defoliation frequency and intensity, as well as leaf longevity, grazing efficiency was calculated at the different sites within the same signal grass sward (Figure 5A). It was observed that

the quadratic model adequately fit ($p < 0.05$) the data on grazing efficiency, achieving the maximum value (98%) at the pasture site with 35-cm tall plants.

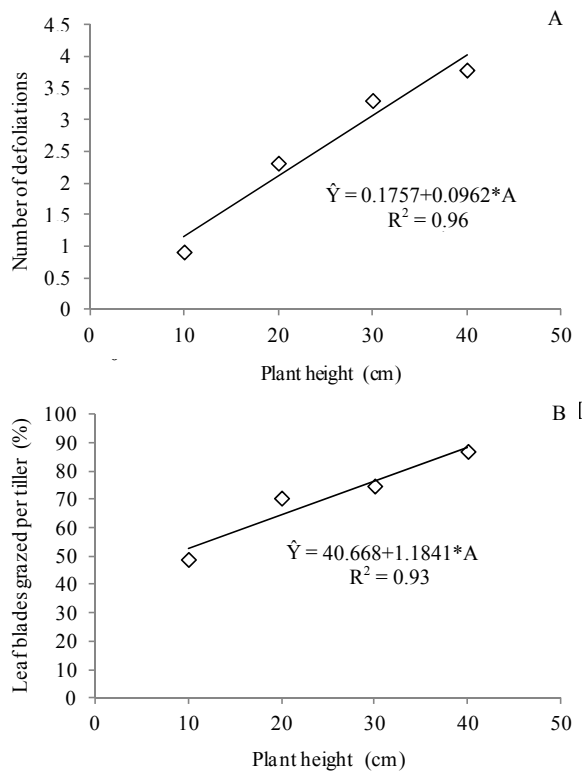


Figure 4. Possible number of defoliations (A) in leaf blades and percentage of leaf blades grazed per tiller (B) of *B. decumbens* cv. Basilisk as a function of plant height in the same sward; *Significant according to t-test ($p < 0.05$).

The highest grazing efficiencies occurred in plant with greater initial height, as they had their leaf blades defoliated more frequently (Figure 2) and intensely (Figure 3) throughout the lifespan of the leaf.

Additionally, it was observed that grazing efficiency values were high, especially at sites with 30- and 40-cm tall plants, which may have been the result of the negative variation in the height of these plants, which maintained or decreased their size during the evaluation period; this indicates that the forage removal process, via animal intake, tended to be greater than the growth of these plants.

Otherwise, the response pattern to forage loss was adjusted according to the quadratic and negative model ($p < 0.05$), the minimum value of which was 2% at the pasture site with 35 cm plants (Figure 5B). This result indicates that forage loss from leaf senescence was reduced in taller plants.

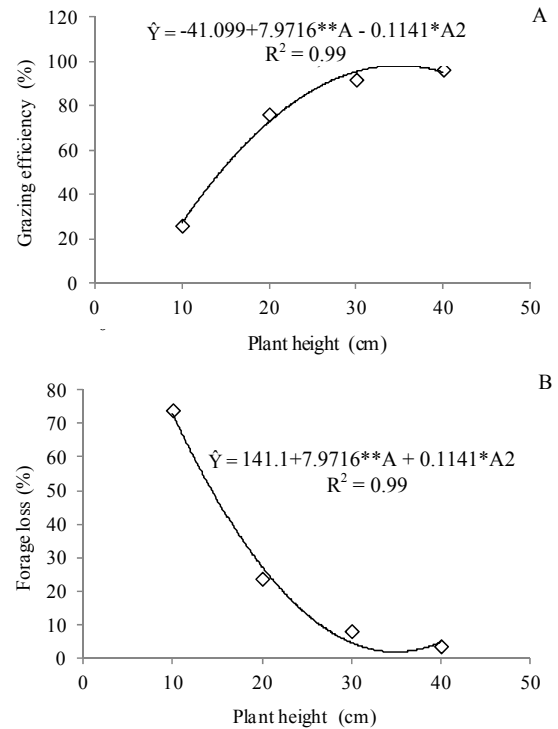


Figure 5. Grazing efficiency (A) and forage loss (B) as a function of plant height in the same sward of *B. decumbens* cv. Basilisk; *Significant according to t-test ($p < 0.01$).

Grazing efficiency decreases in tall plants from pastures with greater mean height, as stocking density is lower under those conditions (LEMAIRE et al., 2009). Contrariwise, in this study taller plants (30 and 40 cm) on the sward averaging 25 cm showed higher grazing efficiency (Figure 5A), as they had been defoliated more frequently and intensely by cattle, showing their preference for grazing this morphological plant group.

In this context, the different patterns of defoliation and sward use by cattle in the horizontal plane of the pasture (Figures 2, 3, 4 and 5), combined with the variations in plant development (SANTOS et al., 2011a), result in temporal and spatial dynamics of the structure of signal grass swards under continuous stocking, which can be evaluated by the temporal variation in the height of plants in the same sward.

The percentage variation in the height of signal grass plants under grazing showed a negative linear response ($p < 0.10$) to initial height (Figure 6). The model indicates there was a height increase of approximately 64.2% over a one-month period in tillers with 10 cm at the start of the evaluation. The same response pattern was observed for the plants with initial height of 20 cm; however, the magnitude of the increase was lower (about 35.9%). On the other hand, in plants with initial height of 30 cm there was practically no percentage variation in

height (7.6%), whereas in those originally with 40 cm there was a reduction of approximately 21% in initial height.

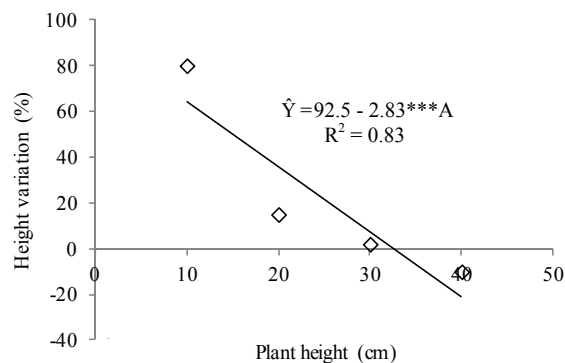


Figure 6. Percentage height variation as a function of initial height of plants in the same sward of *B. decumbens* cv. Basilisk; **Significant according to t-test ($p < 0.05$).

These results demonstrate that signal grass sward structure changes over time, even if the pasture is subjected to the same management criterion – continuous stocking with variable stocking density to keep mean height at 25 cm. The change in vertical sward structure was confirmed by the variation in plant height at each evaluated pasture site, whereas changes to horizontal structure were observed from the changes in height values for plants at different points of the same sward over time.

While the shortest plants in the sward (10 and 20 cm) increased in height, taller plants (30 and 40 cm) were generally reduced in height (Figure 6). This compensation, characterized by greater defoliation of tall plants and lower in short plants, was responsible for the relatively constant mean height of pasture at 25 cm, which represents dynamic equilibrium.

The height increase for shorter plants (10 cm) (Figure 6) further allows us to infer that the high intensity (Figure 3) and frequency (Figure 2) of grazing occurred for short periods in these plants, which is desirable. Conversely, the height reduction for taller plants (40 cm) makes it evident that the structure of signal grass was not compromised, which would certainly have occurred had those plants increased further in height. This response pattern can explain the reason signal grass swards should be maintained at about 25 cm in height under continuous stocking (SANTOS et al., 2011b).

In most Brazilian studies in which defoliation patterns were evaluated in individual tillers, the results were expressed only with regard to the tillers located at sites that represented average sward

conditions (LEMAIRE et al., 2009). Therefore, other sites in the same sward, with deviations regarding their average condition, were not evaluated. In that context, the data presented herein are original, as they refer to defoliation patterns in tillers present at four separate sites in the same sward.

Furthermore, the results make it possible to infer that there is interdependence between the defoliation patterns made by cattle and the spatial variability of vegetation or horizontal sward structure; the latter in turn alters the defoliation patterns of individual tillers, in effect changing the ingestive behavior of animals.

It should be highlighted that no differences were observed in this work regarding the response pattern of the variables measured at both evaluation cycles (cycle 1: February to March; cycle 2: March to April), even though the second cycle occurred during a period of more limiting climate conditions for sward growth, which also tends to stimulate plant blooming.

Conclusion

The presence of plants with various heights in the same sward of *B. decumbens* cv. Basilisk, managed under continuous stocking, alters defoliation patterns and forage usage by cattle, which contributes to generate spatial variability in the vegetation. Sward structure, characterized by the diversity in plant height, is concomitantly the cause and consequence of defoliation patterns in individual tillers that occur in horizontal sward structure.

References

- BARTHAM, G. T.; GRANT, S. A. Defoliation of ryegrass-dominated swards by sheep. **Grass and Forage Science**, v. 39, n. 3, p. 211-219, 1984.
- CARVALHO, P. C. F.; TRINDADE, J. K.; MEZZALIRA, J. C.; MEZZALIRA, J. C.; POLI, C. H. E. C.; NABINGER, C.; GENRO, T. C. M.; GONDA, H. L. Do bocado ao pastoreio de precisão: compreendendo a interface planta-animal para explorar a multifuncionalidade das pastagens. **Revista Brasileira de Zootecnia**, v. 38, supl. esp., p. 109-122, 2007.
- GONÇALVES, E. N.; CARVALHO, P. C. F.; KUNRATH, T. R.; CARASSAL, I. J.; BREMM, C.; FISCHER, V. Relações planta-animal em ambiente pastoril heterogêneo: processo de ingestão de forragem. **Revista Brasileira de Zootecnia**, v. 38, n. 9, p. 1655-1662, 2009.
- LEMAIRE, G.; DA SILVA, S. C.; AGNUSDEI, M.; WADE, M.; HODGSON, J. Interactions between leaf

lifespan and defoliation frequency in temperate and tropical pastures: a review. **Grass and Forage Science**, v. 64, n. 4, p. 341-353, 2009.

PENNING, P. D.; PARSONS, A. J.; ORR, R. J.; TREACHER, T. T. Intake and behaviour responses by sheep to changes in sward characteristics under continuous stocking. **Grass and Forage Science**, v. 46, n. 1, p. 15-28, 1991.

PONTES, L. S.; CARVALHO, P. C. F.; NABINGER, C.; SOARES, A. B. Fluxo de biomassa em pastagem de azevém anual (*Lolium multiflorum* Lam.) manejada em diferentes alturas. **Revista Brasileira de Zootecnia**, v. 33, n. 3, p. 529-537, 2004.

SANTOS, M. E. R.; FONSECA, D. M.; EUCLIDES, V. P. B.; RIBEIRO JÚNIOR, J. I.; BALBINO, E. M.; CASAGRANDE, D. R. Valor nutritivo da forragem e de seus componentes morfológicos em pastagens de *Brachiaria decumbens* diferida. **Boletim de Indústria Animal**, v. 65, n. 4, p. 301-311, 2008.

SANTOS, M. E. R.; FONSECA, D. M.; SILVA, G. P.; PIMENTEL, R. M.; CARVALHO, V. V.; SILVA, S. P.

Estrutura do pasto de capim-braquiária com variação de alturas. **Revista Brasileira de Zootecnia**, v. 39, n. 10, p. 2125-2131, 2010.

SANTOS, M. E. R.; FONSECA, D. M.; BRAZ, T. G. S.; SILVA, S. P.; GOMES, V. M.; SILVA, G. P. Características morfológicas e estruturais de perfilhos em locais do pasto de capim-braquiária com alturas variáveis. **Revista Brasileira de Zootecnia**, v. 40, n. 3, p. 535-542, 2011a.

SANTOS, M. E. R.; FONSECA, D. M.; GOMES, V. M.; ALBINO, R. L.; SILVA, S. P.; SANTOS, A. L. Número de perfilhos do capim-braquiária em regime de lotação contínua. **Acta Scientiarum. Animal Sciences**, v. 3, n. 1, p. 1-7, 2011b.

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